COMPOST AND BIOGAS PRODUCTION FOR SMALL DUAL ENGINES AND AGRICULTURAL DEVELOPMENT

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ABSTRACT

In developing countries, specially sub-arid areas, agricultural development is mainly limited by drought, low soil fertility and energy supply of rural communities. Biogas technology can be a good alternative for organic matter and fuel production, in order to hold and increase soil fertility and to supply small pumping sets for irrigation.

A continuous anaerobic fermenter, called "Transpaille", has been designed to process all types of agricultural residue (straw, cowdung, weeds,...) without any pre-treatment. The fermenter is coupled to a small dual engine in the range up to 12 KW. Electricity generation is the most adaptable transformation of energy for different agricultural or social uses : pumping, grinding of grain,lighting, cooling,... After a finishing period, effluents of the fermenter can be spread in the fields, to increase crop yields. The complete system, including fermenter, engine, irrigation and compost spreading, has been field-tested in Senegal for 4 years with good results. Since 1985 a demonstration project phase has therefore begun in 4 African countries with different applications : irrigated areas of less than 5 hectares, corn grinding for animal or human consumption, and crop transformation.
This paper presents the technical results of biogas and compost production and use, and the first socio-economic appraisal of the system for irrigated areas.

1 - THE "TRANSPAILLE" FERMENTER - PRODUCTION OF BIOGAS AND COMPOST

The process of fermentation is based on a system of compression and transfer of the heterogeneous substrate in immersion in a horizontal cylindrical tank (see figure 1). Normally the fermenter is loaded once a day with a maximum rate of 6 kg TS/m^3 fermenter/day (TS : Total solid). At each load there is a corresponding evacuation of effluent in the catch pit located at the end of the fermenter. The main characteristics and performances of the "Transpaille" fermenter are the following :

- useful volume : 3 to 50 m3 depending on the application,which is 18 to 300 kg TS/day of substrate to be processed.
- production of biogas for a load of 6 kg TS/m3 fermenter/day of straw containing manure (65 % straw) is, according to temperature :

Fermentation temperature (°C)	25	30	35
Biogas productivity (m3/m3 ferm./d)	0.55	0.76	1.0

- compost production : 60 % of the initial quantity of total solids, that is a maximum amount of 3.6 kg TS/m3 ferm/day to be used as organic fertilizer.

2 - SMALL DUAL ENGINES - ELECTRICITY GENERATION

The biogas produced by the fermenter is stored in a flexible gasholder at a pressure of 10 to 15 mbars (fig. 1).

Dual engines of the SCHULE company (West Germany), are characterized by a low rotation speed and a very strong construction. Energy supply is either by fuel oil alone,or a biogas/fuel oil mixture. The performances noted on our demonstration sites are the following in the 5 to 10 KW range :

- fuel oil alone : 0.37 l/KW/h
- dual fuel oil/biogas : 0.62 m3 biogas/KW/h (biogas 60 % CH_4)
  0.095 l fuel oil/KW/h
  or 80 % biogas - 20 % fuel oil.

- fuel economy : 0.275 l/KW/h

The engines are equipped,in series,with a hydraulic pump which ensures the functioning of the piston of the fermenter, and a water pump for heat recovery from the cooling system. The calories recovered make it possible to maintain the temperature of the fermenter during cold periods.

The engines are coupled to 3.5 to 7.5 KW generators which supply the electricity necessary for pumping or other purposes. The energy transformation scheme is the following :

	dual fuel engine		generator		electric engine		use
fuel oil/biogas	95 %		77 %		80 %		95 %

So, the energy yield is 60 % of the mechanical power of the engine.In the case of a direct engine to use mechanical coupling,the yield will increase to 90 % (70 % for belt coupling).

This type of coupling however is less flexible as it does not allow a diversification of the use of energy during the year.

3 - USE OF COMPOST - INCREASE IN CROP YIELDS, AND RESTORING FERTILITY

In the case of an irrigation scheme in the Sudan-sahelian zone, compost is the most important product for ensuring long term investment profitability. The maintaining of crop yields depends on the improvement of cultivated soils. Experiments carried out in Senegal, Niger and Burkina Faso on various tropical crops have given positive medium term results (2 to 3 years of supply) for compost doses of 3 to 4 tons TS/ha (tab.1). In the long term, the results will further improve in comparaison with non-composted soil.

Table 1 : Yield increase for different crops and compost doses.

Crops	Compost Dose (t/ha)	Yield increase (%)
Millet	3	30
Maize	4	20
Sorghum	4	20
Groundnut	3	0 to 20
Tomato	4	25
Onion	4	20
Eggplant	4	20

The increase in yields also makes it possible to increase the production of crop waste, thereby regularly feeding the fermenter.

4 - FIRST ECONOMIC RESULTS IN NIGER

In the framework of the demonstration phase, an irrigation scheme was installed at Lossa in Niger. The total surface area of 3 ha is managed by 6 farmers grouped in cooperation. The technical and economic feasibility of the biogas compost small-scale irrigation chain has been evaluated :

Equipment for the scheme consists of :

- a stable for 10 heads of cattle,
- a Transpaille fermenter with a useful volume of 20 m3, with finishing pits for the compost,
- a dual 7,5 KW generating unit.
- a centrifugal irrigation pump operating from a branch of the Niger river - 5.5 KW - 37 m3/h at 20 m head.
- a combined low pressure/sprinkler irrigation network over 3 ha.

The functioning of the irrigation scheme is given in figure 2. The total cost of the equipment is estimated at 15.5 million CFA francs, of which 5.8 million are required for the Transpaille installation. The farmers participated in all the installation works.

After a year of farming, the economic results compared to a traditional irrigation scheme not including the biogas-compost chain, are as follows :

- energy aspects :

1450 hours of pumping. Power supplied : 5,5 KW with an economy of 3,400 l of fuel oil/year, that is 80,000 FCFA/year.

- agronomic aspects :

An increase in yield for 3 ha of sorghum and 0.5 ha of market-garden crops, that is 420,000 FCFA/year. The total gain resulting from the biogas-compost chain is 1,100,000 FCFA/year. On the basis of a loan at constant 5 % interest over 10 years, it takes 7 years for the "Transpaille" installation to produce a return on investment.

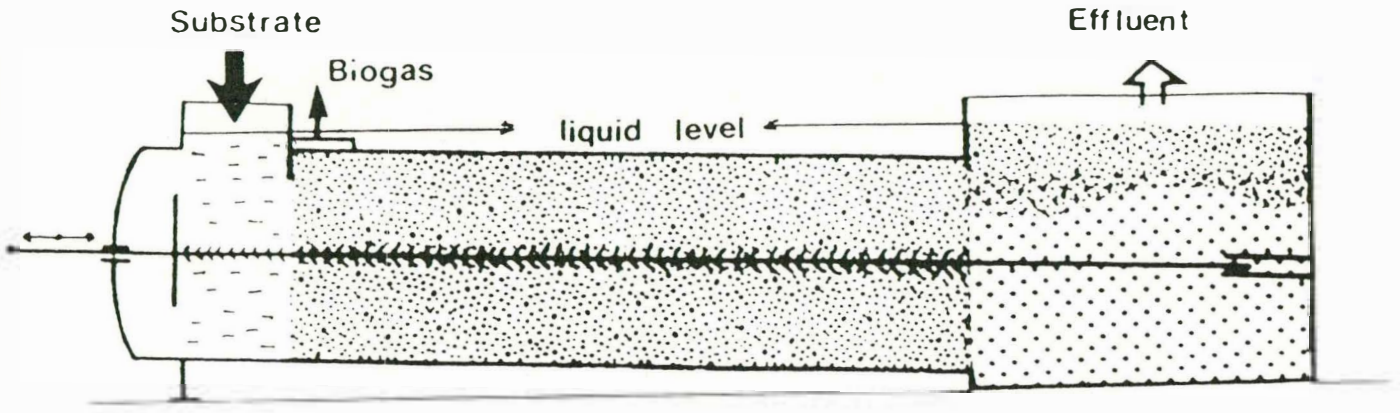
CONCLUSIONS AND PROSPECTS

After 3 years of testing, which have confirmed the technical references of the "Transpaille" integrated system, the first results of the demonstration phase carried out in 4 African countries (Niger, Senegal, Togo and Sudan) and in different activity sectors, confirm its technical and economical feasibility.

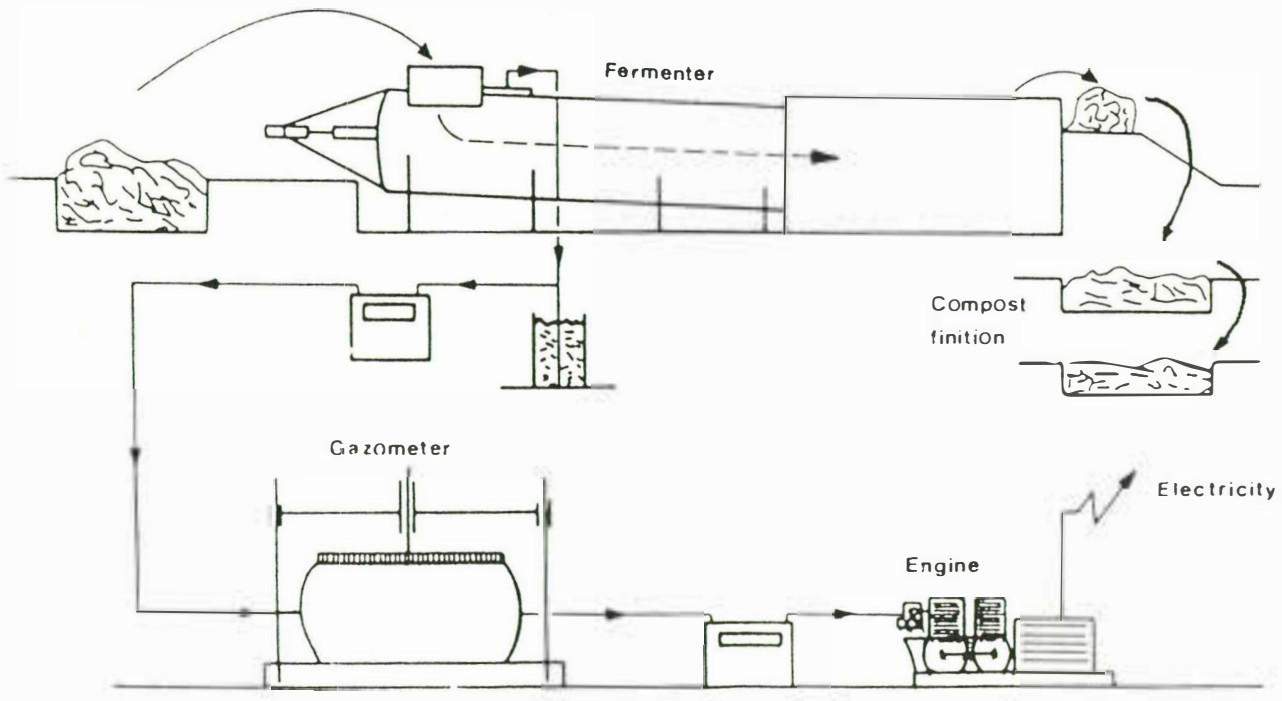
The technology transfer will begin in 1987 with equipment programmes on a regional scale in many African countries.

The technical evolution of the "Transpaille" process is continuing towards its specific application in the food industries in European and tropical countries.

FIGURE 1



Transpaille fermenter



Complete Transpaille system

FIGURE 2 - ANNUAL FONCTIONNING OF IRRIGATION SCHEME (NIGER)